# Application of InSAR Technique in Deformation Monitoring of Water Conservancy and Hydropower Engineering

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## ABSTRACT

- The deformation of reservoir bank slopes and water conservancy and hydropower engineering facilities is related to the operation safety of water conservancy and hydropower projects. Based on the multi-temporal Sentinel-1 images, the time series InSAR technique was used to carry out a demonstration application in the Xiaolangdi Multipurpose Dam Project. Four small areas with large deformation rate monitoring points were found on the slope of the reservoir bank in the key area of the north bank of Xiaolangdi. The deformation rate of the monitoring points mainly concentrated in -10mm~ -25mm/yr. In the central area of the crest of the Xiaolangdi Dam, a large deformation accumulation area with an annual deformation amount of -60mm/year was found in the satellite line of sight. Before January 2021, the deformation amount increased rapidly. From January to March 2021, the deformation is slowing down. The InSAR technique can quickly obtain the deformation information of water conservancy and hydropower engineering facilities and reservoir bank slopes, which can be used as a common monitoring method for monitoring the safe operation of water conservancy projects.

## INTRODUCTION

- Water conservancy and hydropower projects often have the characteristics of wide coverage and complex geological and climatic conditions in the region.
- The construction and maintenance costs of GNSS are high, and the monitoring range is limited, which makes it difficult to be widely used.
- InSAR technique can quickly obtain large-scale and high-precision deformation monitoring information. It is a potential space-to-earth observation technique in water conservancy and hydropower engineering facilities and reservoir-bank geological disaster deformation monitoring.
- In this article， the demonstration application of InSAR technique has been carried out in water conservancy hydropower projects.

## STUDY AREA AND DATASETS

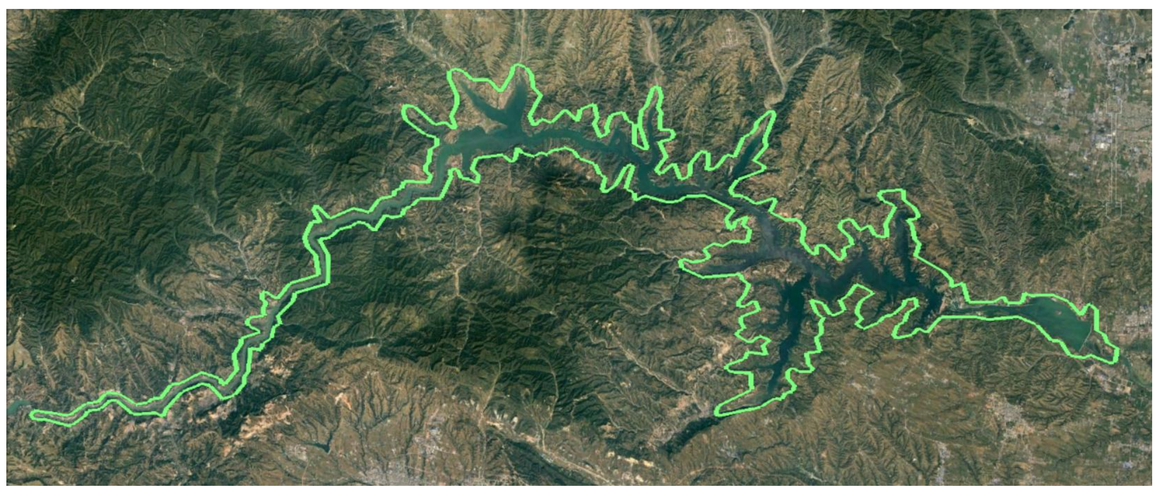

Figure 1. The location of Xiaolangdi Water Conservancy project

- Xiaolangdi Water Conservancy project is the key control project of the Yellow River management and development, which is one of the most iconic masterpieces in the history of water conservancy projects in the world. Long-term, stable and large area deformation monitoring of Xiaolangdi hydraulic project is very important for the safe operation of Xiaolangdi.

- The 22 Sentinel-1 images covering Xiaolangdi from August 2020 to April 2021 were used and processed by SBAS-InSAR to obtain the deformation distribution of Xiaolangdi.

Table 1. Sentinel-1 Images

| No | Date | No | Date | No | Date | No | Date | No | Date | No | Date |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 20200818 | 5 | 20201005 | 9 | 20201122 | 13 | 20210109 | 17 | 20210226 | 21 | 20210415 |
| 2 | 20200830 | 6 | 20201017 | 10 | 20201204 | 14 | 20210121 | 18 | 20210310 | 22 | 20210427 |
| 3 | 20200911 | 7 | 20201029 | 11 | 20201216 | 15 | 20210202 | 19 | 20210322 | | |
| 4 | 20200923 | 8 | 20201110 | 12 | 20201228 | 16 | 20210214 | 20 | 20210403 | | |

## METHOD

- SBAS-InSAR composes SAR images into several sets according to certain space-time baseline conditions to ensure the high coherence of the interferometric combination. By extracting the high-coherence points with relatively stable reflection characteristics in the interference combination, the deformation phase of the high-coherence points is solved by the least squares or singular value decomposition (SVD) method, and the ground deformation is extracted with high precision.

## RESULTS AND ANALYSIS

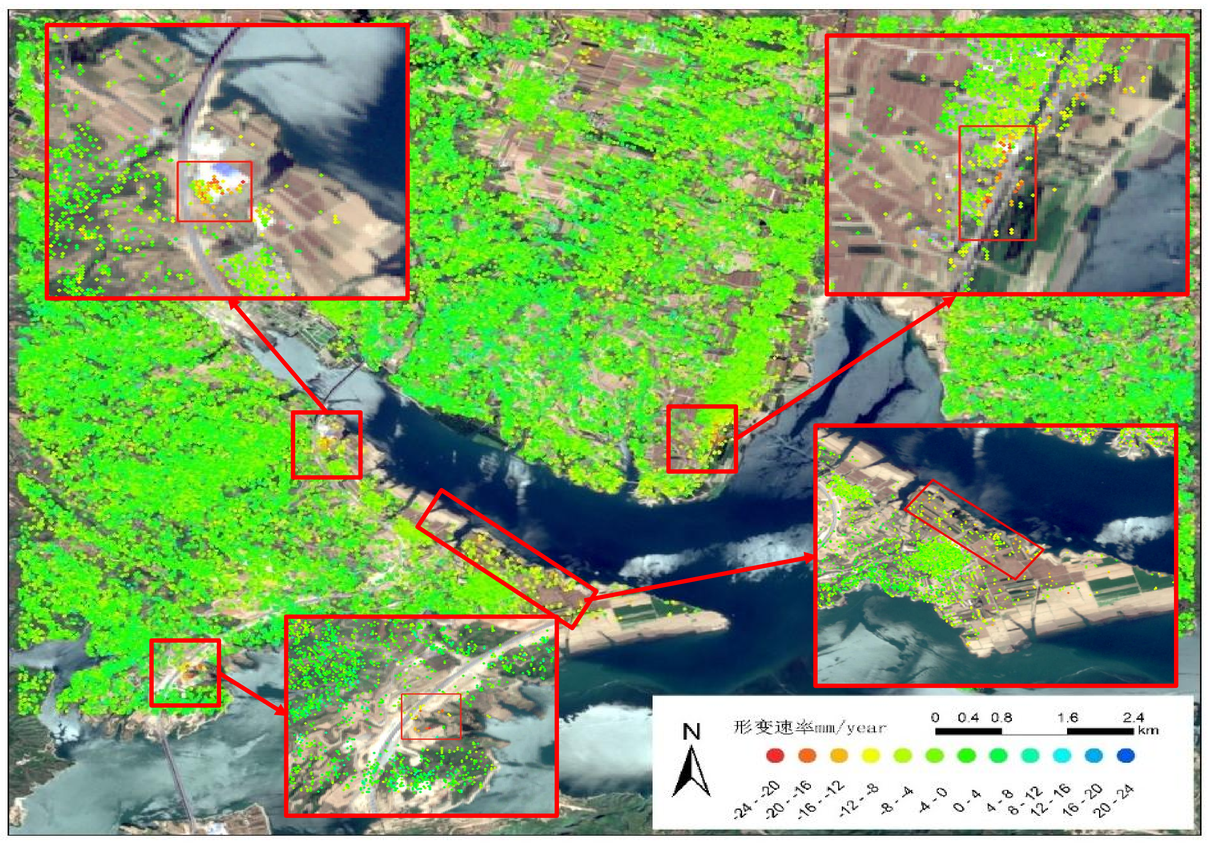


Figure 2. The deformation distribution of bank slope of Xiaolangdi Reservoir

- The slope of the reservoir bank in the key area on the north bank of Xiaolangdi is in a stable state as a whole, and the deformation of a small part of the bank slope is large.
- Find the deformation areas with large local deformation variables and relatively concentrated distribution, and delineate 4 suspected hidden danger areas with large deformation, see right picture.

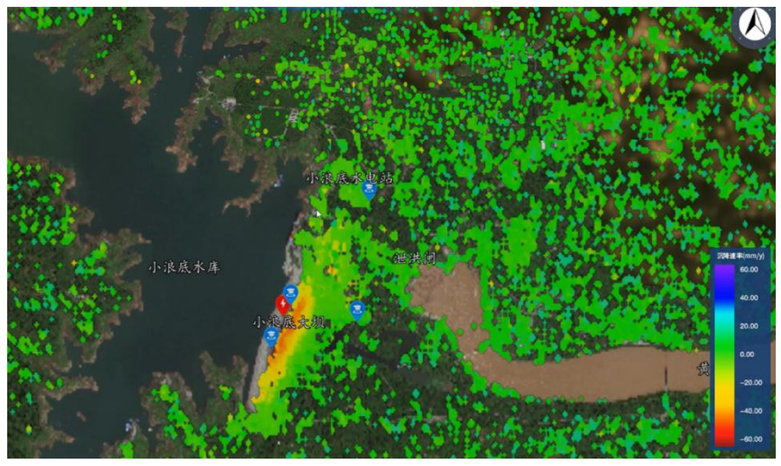


Figure 3. The deformation of Xiaolangdi in Line of Sight Direction

- Obvious deformation with velocity exceeding 60 mm/year are found at the dam body.
- The Xiaolangdi dam crest shows a deformation characteristic that the deformation increases at a constant speed before January 2021. From January to March 2021, the deformation increased slowly.
- The deformation at the bottom and surrounding of the Xiaolangdi dam is small and relatively stable as a whole.

## CONCLUSION

- Four small areas with large deformation rate monitoring points were found on the slope of the reservoir bank in the key area of the north bank of Xiaolangdi. Velocity of the monitoring points mainly concentrated in -10mm/yr~-25mm/yr.
- In the central area of the crest of the Xiaolangdi Dam, a large deformation accumulation area with an annual deformation amount of -60mm/year was found in the satellite line of sight. Before January 2021, the deformation amount increased rapidly. From January to March 2021, the deformation is slowing down.
- The InSAR technique can quickly obtain the deformation information of water conservancy and hydropower engineering facilities and reservoir bank slopes, which can be used as a common monitoring method for monitoring the safe operation of water conservancy projects.

## REFERENCE

- Berardino P, Fornaro G, Lanari R, et al. A new algorithm for surface deformation monitoring based on small baseline differential SAR interferograms[J]. IEEE Transactions on Geoscience and Remote Sensing, 2002, 40(11): 2 375-2 383.
- Xu Dongbiao, Feng Han, Yan Shiyong. Deformation Monitoring for Structural Health of Xiaolangdi Dam with Sentinel-1A Based on DS-InSAR.China Rural Water and Hydropower, 2020(6): 165-170.